MILITARY SPECIFICATION

SEMICONDUCTOR DEVICE, TRANSISTOR, NPN, SILICON, POWER
TYPES 2N5152, 2N5154, JAN, JANTX & JANTXV

This specification is approved for use by the Rome Air Development Center, Department of the Air Force, and is available for use by all Departments and Agencies of Defense.

1. SCOPE

1.1 Scope. This specification covers the detail requirements for NPN, silicon, power transistors for use in high-speed power-switching applications. Three levels of product assurance are provided for each device type as specified in MIL-S-19500.

1.2 Physical dimensions. See Figure 1 (TO-39)

1.3 Maximum ratings.

P_T 1/ $T_A = 25^oC$	P_T 2/ $T_C = 25^oC$	V_{CBO}	V_{CEO}	V_{EBO}	I_C	I_C 3/	Reverse Pulse 4/ Energy	Safe Operating Area	T_{stg}
W 1	W 11.8	Vdc 100	Vdc 80	Vdc 5.5	Adc 2	Adc 10	mJ 15	See Figure 5	^oC -65 to +200

1/ Derate linearly 5.7 mw/^{o}C for $T_A > 25^oC$
2/ Derate linearly 66.7 mw/^{o}C for $T_C > 25^oC$
3/ This value applies for $Pw \leq 8.3$ ms, duty cycle $\leq 1\%$
4/ This rating is based on the capability of the transistors to operate safely in the unclamped inductive load energy test circuit of Figure 4.

1.4 Primary electrical characteristics at $T_C = 25^oC$.

LIMITS	h_{FE2} 1/ V_{CE} = 5V, I_C = 2.5A		$\lvert h_{fe} \rvert$ V_{CE} = 5V, I_C = 500 mA, f = 10 MHz		$V_{BE(sat)2}$ I_C = 5 Adc, I_B = 500 mAdc	$V_{CE(sat)2}$ I_C = 5 Adc, I_B = 500 mAdc	C_{obo} V_{CB} = 10Vdc, I_E = 0, f = 1 MHz	$R_{\theta J-C}$
	2N5152	2N5154	2N5152	2N5154				
Min	30	70	6	7	Vdc --	Vdc --	pF --	$^oC/W$ --
Max	90	200	--	--	2.2	1.5	250	15

1/ Pulsed (See 4.5.1)

Beneficial comments (Recommendations, additions, deletions) and any pertinent data which may be used in improving this document should be addressed to: Rome Air development Center, RADC, Griffiss AFB, NY 13441 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

2. APPLICABLE DOCUMENTS

2.1 Issues of documents. The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of the specification to the extent specified herein.

SPECIFICATION

MILITARY

MIL-S-19500 - Semiconductor Devices, General Specification for.

STANDARD

MILITARY

MIL-STD-750 - Test Methods for Semiconductor Devices

(Copies of specifications, standards, drawings, and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer).

3. REQUIREMENTS

3.1 Detail Specification. The individual item requirements shall be in accordance with MIL-S-19500 and is specified herein.

3.2 Abbreviations, symbols and definitions. The abbreviations, symbols and definitions used herein are defined in MIL-S-19500.

3.3 Design, construction and physical dimensions. The design, construction and physical dimensions shall be as specified in MIL-S-19500 and Figure 1 herein.

3.3.1 Lead Material and Finish. Lead material shall be kovar or alloy 52. Lead finish shall be gold plated, tin plated or solder dipped. Where a choice of lead material or finish is desired, it shall be specified in the contract or procurement document. (See 6.3)

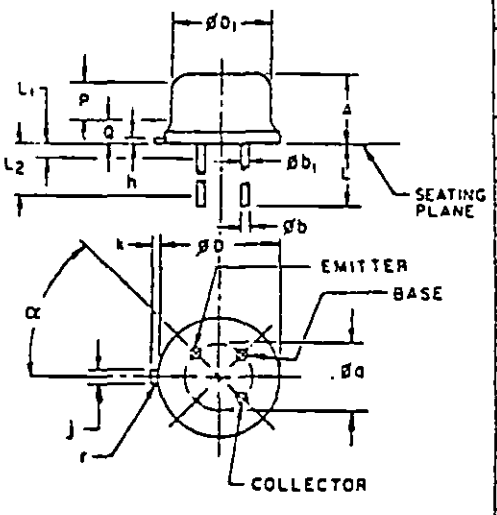
3.3.2 Current Density. Current density of internal conductors shall be as specified in 3.6.5 of MIL-S-19500.

3.4 Marking. Marking shall be in accordance with MIL-S-19500, except country of origin may be omitted.

4. QUALITY ASSURANCE PROVISIONS

4.1 Sampling and inspection. Sampling and inspection shall be accordance with MIL-S-19500, and as specified herein.

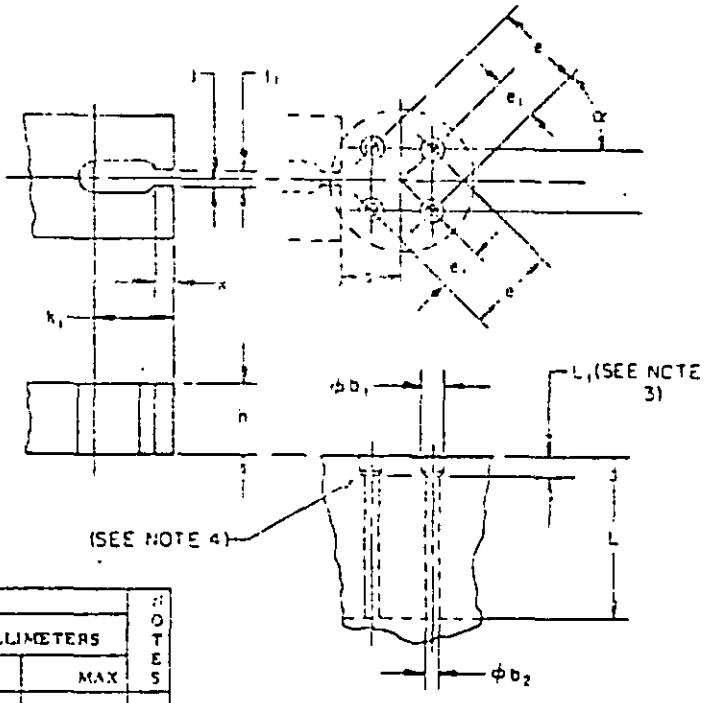
4.2 Qualification inspection. Qualification inspection shall be in accordance with MIL-S-19500.



LTR	DIMENSIONS				NOTES
	INCHES		MILLIMETERS		
	MIN	MAX	MIN	MAX	
A	.240	.260	6.10	6.60	
Øa	.200 TP		5.08 TP		6
Øb	.016	.021	.41	.53	7, 8
$Øb_1$	.016	.019	.41	.48	7, 8
ØD	.335	.370	8.51	9.40	
$ØD_1$	.305	.335	7.75	8.51	
h	.009	.041	.23	1.04	
j	.028	.034	.71	.86	2
k	.029	.045	.74	1.14	3
L	.500	.750	12.70	19.05	7, 8
L_1	---	.050	---	1.27	7, 8
L_2	.250	---	6.35	---	7, 8
P	.100	---	2.54	---	5
Q	---	.050	---	1.27	4
r	---	.010	---	.25	10
α	45° TP		45° TP		6

NOTES:
1. Metric equivalents (to the nearest .01 mm) are given for general information only and are based upon 1 inch = 25.4 mm.
2. Beyond r (radius) maximum, j shall be held for a minimum length of .011 (.28 mm).
3. k measured from maximum OD.
4. Outline in this zone is not controlled.
5. OD_1 shall not vary more than .010 (.25 mm) in zone P. This zone is controlled for automatic handling.
6. Leads at gage plane .054 +.001 -.000 (1.37 +.03 -.00 mm) below seating plane shall be within .007 (.18 mm) radius of true position (TP) at maximum material condition (MMC) relative to tab at MMC. The device may be measured by direct methods or by the gage and gaging procedure shown in figure 2.
7. Ob_1 applies between L_1 and L_2. Ob applies between L_2 and L minimum. Diameter is uncontrolled in L_1 and beyond L minimum.
8. All three leads.
9. The collector shall be electrically and mechanically connected to the case.
10. r (radius) applies to both inside corners of tab.

FIGURE 1. Physical dimensions



LTR	DIMENSIONS				NOTES
	INCHES		MILLIMETERS		
	MIN	MAX	MIN	MAX	
ϕb_1	.0595	.0605	1.51	1.54	
ϕb_2	.0325	.0335	.83	.85	
e	.1995	.2005	5.07	5.09	
e_1	.0995	.1005	2.53	2.55	
h	.150 Nominal		3.81 Nominal		
l_1	.0175	.0190	.44	.48	
l_2	.0350	.0355	.89	.90	
x	.009	.011	.22	.28	
r_1	.125 Nominal		3.18 Nominal		
	.272	.278	6.45	7.60	

NOTES:
1. The location of the tab locator within the limits indicated will be determined by the tab and flange dimensions of the device being checked.
2. Gaging procedure. The device being measured shall be inserted until its seating plane is .125 ± .010 (3.18 ± .25 mm) from the seating surface of the gage. A force of 8 ± .5 oz shall then be applied parallel and symmetrical to the device's cylindrical axis. When examined visually after the force application (the force need not be removed) the seating plane of the device shall be seated against the gage. The use of a pin straightener prior to insertion in the gage is permissible.
3. Gaging plane.
4. Drill angle.

FIGURE 2. Gage for lead and tab location

4.3 Screening JANTX and JANTXV levels only. Screening shall be in accordance with MIL-S-19500 (Table II) and as specified herein. The following measurements shall be made in accordance with Table I herein. Devices that exceed the limits of Table I herein shall not be accepted.

Screen (see Table II of MIL-S-19500)	Measurements JANTX, JANTXV levels
11	I_{CES1} and h_{FE2}
12	See 4.3.1
13	Subgroup 2 of Table I herein: I_{CES_1} = +100% of initial value or 100 na whichever is greater $\Delta h_{FE2} = \pm 20\%$

4.3.1 Power burn-in conditions. Power burn-in conditions (TX and TXV) are as follows.

2N5152, 2N5154 V_{CE} = 40V P_t = 1.0W T_A = 25 $\pm$ 3°C

NOTE: No heat sink or forced air cooling on the device shall be permitted.

4.4 Quality conformance inspection. Quality conformance inspection shall be in accordance with MIL-S-19500.

4.4.1 Group A inspection. Group A inspection shall be conducted in accordance with MIL-S-19500 and Table I herein. Endpoint electrical measurements shall be in accordance with the applicable steps of Table IV, herein.

4.4.2 Group B inspection. Group B inspection shall be conducted in accordance with the conditions specified for subgroup testing in Table IVb (JAN, JANTX, and JANTXV) of MIL-S-19500, and Table II herein. Electrical measurements (end points) and delta requirements shall be in accordance with the applicable steps of Table IV herein.

4.4.3 Group C inspection. Group C inspection shall be conducted in accordance with the conditions specified for subgroup testing in Table V of MIL-S-19500 and Table III herein. Electrical measurements (endpoints) and delta requirements shall be in accordance with the applicable steps of Table IV herein.

TABLE I Group A inspection

Examination or test	MIL-STD-750		LTPD		Limits		
	Method	Conditions	JAN/TX TXV	Symbol	Min	Max	Units
Subgroup 1			5				
Visual and mechanical examination	2071						
Subgroup 2			5				
Breakdown voltage collector to emitter	3011	Bias condition C, I_C = 100 mAdc, I_B = 0, Pulsed (see 4.5.1)		$V_{(BR)CEO}$	80	--	Vdc
Collector to emitter cutoff current	3041	Bias condition C, V_{CE} = 60 Vdc, V_{BE} = 0		I_{CES1}	--	1.0	uAdc
Collector to emitter cuttoff current	3041	Bias condition C, V_{CE} = 100 Vdc, V_{BE} = 0		I_{CES2}	--	1.0	mAdc
Collector to emitter cutoff current	3041	Bias condition D, V_{CE} = 40 Vdc, I_B = 0		I_{CEO}	--	50	uAdc
Emitter to base cutoff current	3061	Bias condition D, V_{EB} = 4 Vdc, I_C = 0		I_{EBO1}	--	1.0	uAdc
Emitter to base cutoff current	3061	Bias condition D, V_{EB} = 5.5 Vdc, I_C = 0		I_{EBO2}	--	1.0	mAdc
Forward - current transfer ratio	3076	V_{CE} = 5 Vdc, I_C = 50 mAdc, Pulsed (see 4.5.1)		h_{FE1}			
2N5152					20	--	--
2N5154					50	--	--
Forward - current transfer ratio	3076	V_{CE} = 5 Vdc, I_C = 2.5 Adc, Pulsed (see 4.5.1)		h_{FE2}			
2N5152					30	90	--
2N5154					70	300	--

TABLE I Group A inspection

Examination or test	MIL-STD-750		LTPD		Limits		
	Method	Conditions	JAN/TX TXV	Symbol	Min	Max	Units
Subgroup 2 (con't)							
Forward - current transfer ratio	3076	V_{CE} = 5 Vdc I_C = 5 Adc Pulsed(see 4.5.1)		h_{FE3}			
2N5152					20	--	--
2N5154					40	--	--
Base-emitter voltage (non-saturated)	3066	Test condition B V_{CE} = 5 Vdc I_C = 2.5 Adc Pulsed(see 4.5.1)		V_{BE}	--	1.45	Vdc
Base-emitter saturation voltage	3066	Test condition A I_C = 2.5 Adc I_B = 250 mAdc Pulsed(see 4.5.1)		$V_{BE(sat)1}$	--	1.45	Vdc
Base-emitter saturation voltage	3066	Test condition A I_C = 5 Adc I_B = 500 mAdc Pulsed(see 4.5.1)		$V_{BE(sat)2}$	--	2.2	Vdc
Collector-emitter saturation voltage	3071	I_C = 2.5 Adc I_B = 250 mAdc Pulsed(see4.5.1)		$V_{CE(sat)1}$	--	0.75	Vdc
Collector-emitter saturattion voltage	3071	I_C = 5 Adc I_B = 500 mAdc Pulsed(see 4.5.1)		$V_{CE(sat)2}$	--	1.5	Vdc
Subgroup 3			5				
High temperature operation:		T_C = 150°C					
Collector to emitter cutoff current	3041	Bias condition A V_{CE} = 60 Vdc V_{BE} = -2 Vdc		I_{CEX}	--	500	µAdc

TABLE I Group A inspection

Examination or test	MIL-STD-750		LTPD	Symbol	Limits		Units
	Method	Conditions	JAN/TX TXV		Min	Max	
Subgroup 3 (con't)							
Low temperature operation:		T_C = -55°C					
Forward - current transfer ratio	3076	V_{CE} = 5 Vdc I_C = 2.5 Adc Pulsed (see 4.5.1)		h_{FE4}			
2N5152					15	--	--
2N5154					25	--	--
Subgroup 4			5				
Common-emitter small-signal short-circuit forward-current transfer ratio	3206	V_{CE} = 5 Vdc I_C = 100 mAdc f = 1 KHz		h_{fe}			
2N5152					20	--	--
2N5154					50	--	--
Magnitude of common-emitter small-signal short-circuit forward-current transfer ratio	3306	V_{CE} = 5 Vdc I_C = 500 mAdc f = 10 MHz		$\lvert h_{fe} \rvert$			
2N5152					6	--	--
2N5154					7	--	--
Open-circuit output capacitance	3236	V_{CB} = 10 Vdc I_E = 0 f = 1 MHz		C_{obo}	--	250	pF

TABLE I Group A inspection

Examination or Test	MIL-STD-750		LTPD		Limits		
	Method	Conditions	JAN/TX TXV	Symbol	Min	Max	Units
Switching time		I_C = 5 Adc I_{B_1} = 500 mAdc		t_{on}	--	0.5	µs
		I_{B_2} = -500 mAdc		t_s	--	1.4	µs
		V_{BE}(off) = 3.7Vdc		t_f	--	0.5	µs
		RL = 6 Ω (see Figure 3)		t_{off}	--	1.5	µs
Subgroup 5							
Safe operating area (D.C.)	3055	Pre-pulse condition for each test: V_{CE} = 0 I_C = 0 T_C = 25°C Pulse condition for each test: t_p = 1 sec. 1 cycle T_C = 25°C (see Figure 5)	10				
Test # 1		V_{CE} = 5.8 Vdc I_C = 2.0 Adc					
Test # 2		V_{CE} = 32 Vdc I_C = 340 mAdc					
Test # 3		V_{CE} = 80 Vdc I_C = 20 mAdc					

TABLE I Group A inspection

Examination or test	MIL-STD-750		LTPD	Symbol	Limits		Units
	Method	Conditions	JAN/TX TXV		Min	Max	
Safe operating area (unclamped inductive)		T_C = 25°C R_{BB_1} = 10 Ω R_{BB_2} = 100 Ω L = 0.3 mH RL = 0.1 Ω V_{CC} = 10 Vdc V_{BB_1} = 10 Vdc V_{BB_2} = 4 Vdc I_{CM} = 10 Adc (see Figure 4)					
End point electrical measurements		See Table IV Steps 1,2,3					
Subgroups 6 and 7							
Not applicable							

TABLE II Group B inspection (all quality levels)

Examination or test	MIL-STD-750		LTPD
	Method	Conditions	
Subgroup 1			15
Solderability	2026		
Resistance to solvents	1022		
Subgroup 2			10
Thermal shock (temperature cycling)	1051		
Hermetic seal a. Fine leak b. Gross leak	1071	a. Test condition G or H Leak rate = $1X10^{-8}$ atm cc/Sec. b. Test condition A,C,D or F	
Electrical measurement		See Table IV, steps 1, 2 and 3	
Subgroup 3			5
Steady state life	1027	340 hrs, V_{CB} = 40 Vdc P_T = 1W, T_A = 25°C	
Electrical measurement		See Table IV, steps 1, 2, 4 and 5	
Subgroup 4			
Decap internal visual design verification	2075		1 device /0 failure for each lot
Bond strength	2037	All internal wires are to be pulled	20 (C=0)
Subgroup 5			15
Thermal resistance	3131	See 4.5.2	

TABLE II Group B inspection (all quality levels)

Examination or test	MIL-STD-750		LTPD
	Method	Conditions	
Subgroup 6			7
High temperature life (non-operating)	1032	T_A = 200°C t = 340 hrs	
Electrical measurement		See Table IV, steps 1, 2, 4 and 5	

TABLE III Group C inspection (all quality levels)

Examination or test	MIL-STD-750		LTPD
	Method	Conditions	
Subgroup 1			15
Physical dimensions	2066	(See figure 1)	
Subgroup 2			10
Thermal shock (glass strain)	1056	Test condition B	
Terminal strength	2036	Test condition E	
Hermetic seal a. Fine leak	1071	a. Test condition G or H Leak rate = 1×10^{-8} atm.cc/sec.	
b. Gross leak		b. Test condition A, C, D or F	
Moisture resistance	1021	Omit initial conditioning	
External visual	2071		
Electrical measurement		See table IV, steps 1 2 and 3	
Subgroup 3			10
Shock	2016		
Vibration, variable frequency	2056		
Constant acceleration	2066	10,000 G	
Electrical measurement		Table IV, steps 1, 2 and 3	
Subgroup 4			15
Salt atmosphere (corrosion)	1041		

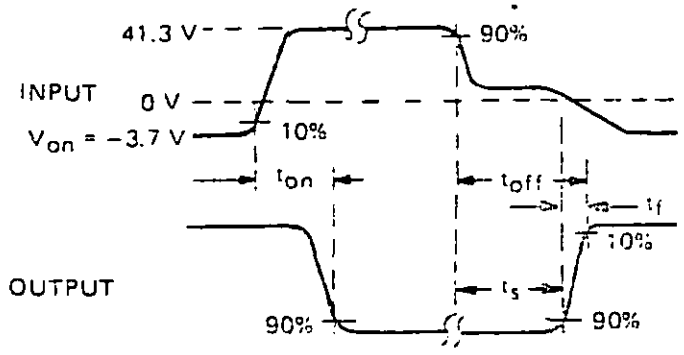
TABLE III Group C inspection (all quality levels)

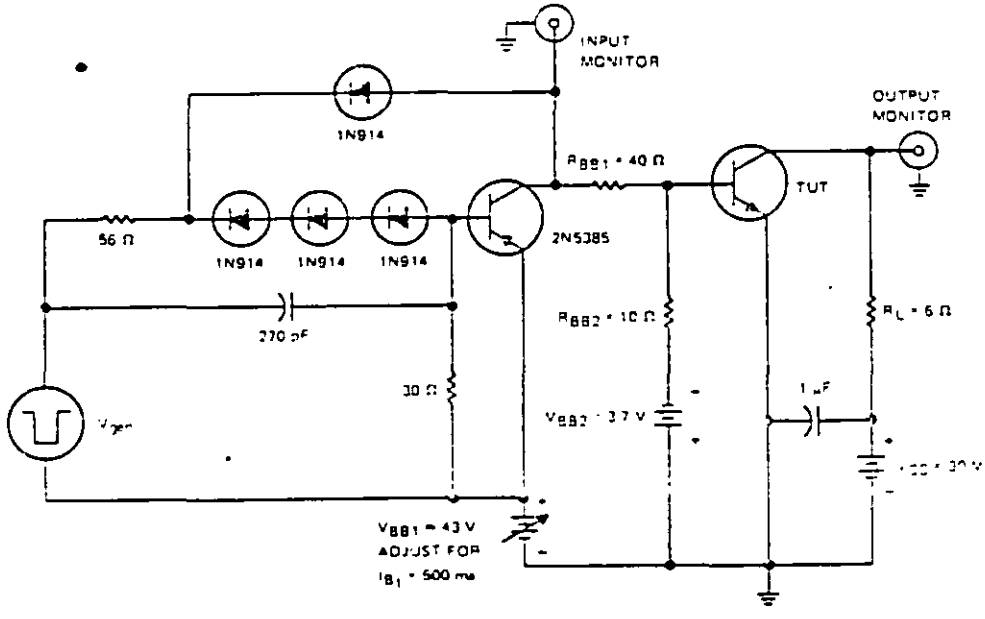
Examination or test	MIL-STD-750		LTPD
	Method	Conditions	
Subgroup 5			
Not applicable			
Subgroup 6			λ=10
Steady state operation life	1026	T_A = 25°C 1000 hours V_{CB} = 40 Vdc P_T = 1 W	
Electrical measurement		Table IV, steps 1, 2, 4 and 5	

TABLE IV Groups A, B and C Electrical Measurements

Steps	Examination or test	MIL-STD-750 Method	MIL-STD-750 Conditions	LTPD JAN/TX TXV	Symbol	Limits Min	Limits Max	Units
1.	Collector to emitter cutoff current	3041	V_{CE} = 60 Vdc		I_{CES1}		1.0	µAdc
2.	Forward - current transfer ratio	3076	V_{CE} = 5 Vdc I_C = 2.5 Adc Pulsed (see 4.5.1)		h_{FE2}			
	2N5152					30	90	--
	2N5154					70	200	--
3.	Breakdown voltage collector to emitter	3011	Bias condition A I_C = 100 mAdc I_B = 0 Pulsed (see 4.5.1)		$V_{(BR)CEO}$	80		Vdc
4.	Collector to emitter cutoff current	3041	V_{CE} = 60 Vdc		I_{CES1} 1/	100% of initial value or 100 nA whichever is greater		
5.	Forward - current transfer ratio	3076	I_C = 2.5 Adc V_{CE} = 5 Vdc Pulsed (see 4.5.1)		h_{FE2} 1/	± 20% change from initial reading		

1/ Devices which exceed the Group A limits for this test shall not be accepted





A. V_{gen} is a -30 V pulse (from 0V) into a 50 ohm termination.

B. The V_{gen} waveforms is supplied by a generator with following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, Z_{out} = 50 ohm, duty cycle $\leq$ 2%, tw = 20 μS.

C. Waveforms are monitored on an oscilloscope with the following charactersitics: $t_r \leq 15$ ns, $R_{in} \geq 10$ M ohm, $C_{in} \leq 11.5$ pF.

D. Resistors must be noninductive types.

E. The d-c power supplies may require additional bypassing in order to minimize ringing.

FIGURE 3 Switching Time Test Circuit

R_{BB1} = 10 Ω
R_{BB2} = 100Ω
L = 0.3 mH
R_L = 0.1 Ω
V_{CC} = 10 V
I_{CM} = 10 A
V_{BB1} = 10 V
V_{BB2} = 4 V

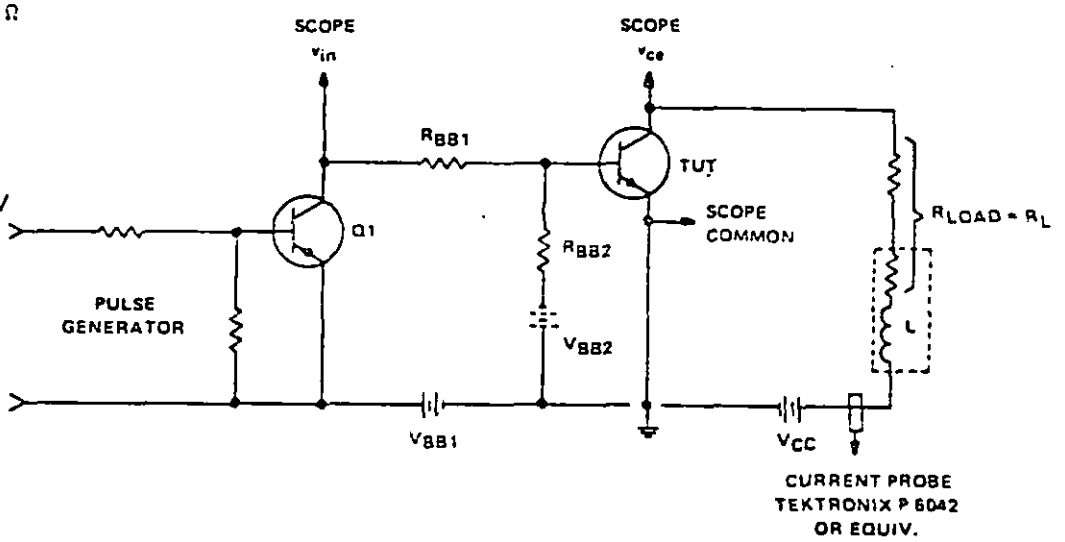


FIGURE 4 Unclamped Inductive Load Energy Test Circuit

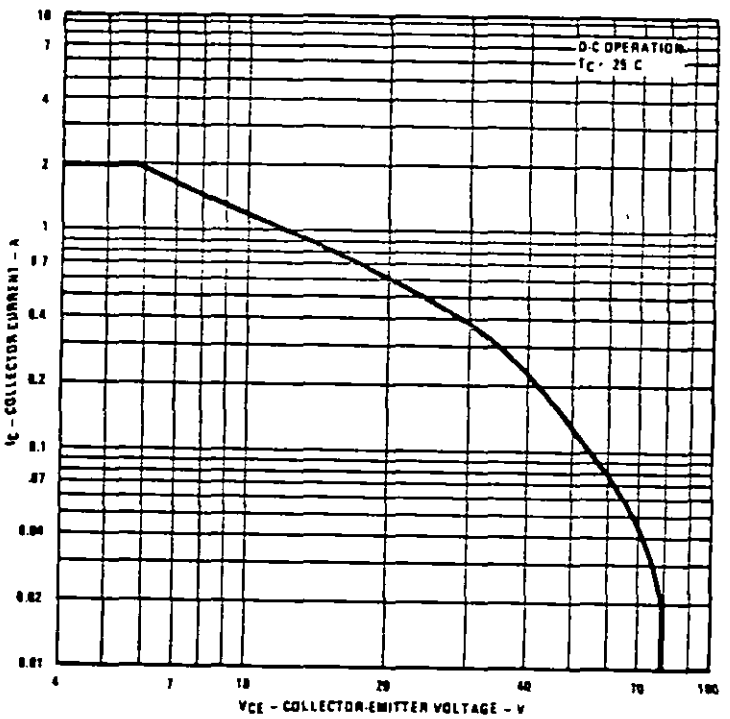


FIGURE 5 Maximum Safe Operating Area

4.5 Methods of examination and test. Methods of examination and test shall be as specified in the appropriate tables and as follows:

4.5.1 Pulse measurements. Conditions for pulse measurements shall be as specified in Section 4 of MIL-STD-750.

4.5.2 Thermal resistance. Thermal resistance measurements shall be conducted in accordance with Method 3131 of MIL-STD-750. The following details shall apply:

a. Collector current magnitude during power application shall be 500 m Adc.
b. Collector to emitter voltage magnitude shall be 10 Vdc.
c. Reference temperature measuring point shall be the case.
d. Reference point temperature shall be within the range $T_C \geq 25^{\circ}C \leq 75^{\circ}C$. Actual temperature shall be recorded.
e. Mounting arrangement shall be with heat sink to case.
f. Maximum limit of $R_{\theta JC}$ shall be 15.0°C/W.

4.5.3 Inspection conditions. Unless otherwise specified herein all inspections shall be conducted at a case temperature (T_C) of 25°C.

5. PACKAGING

5.1 Packaging requirements. The requirements for packaging shall be in accordance with MIL-S-19500.

6. NOTES

6.1 Notes. The notes specified in MIL-S-19500 are applicable to this specification.

6.2 Complimentary Use. The devices specified herein are designed for complimentary use with the 2N5151 and 2N5153.

6.3 Ordering Data. Procurement documents should specify the following:

a. Lead finish (see 3.3.1)

Custodian
Air Force - 17

Preparing activity
Air Force - 17

Review activities
Air Force - 11, 19, , 85, 99
DSA-ES

Agent
DLA-EC

(FSC5961F-791)

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MIL-S-19500/344

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